S P E C I F I C A T I O N

Pseudo Noise Generator

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FIELD OF THE INVENTION

The present invention relates to a pseudo noise generator employed to generate pseudo noise, etc. for evaluate immunity of electric devices against electro-magnetic interference waves.

DESCRIPTION OF PRIOR ART

In case of combining many kinds of noise, or of thermal noise or city noise to one another, amplitude of noise has the Gaussian distribution. In order to simulate generated noises to the Gaussian distribution, there have been proposed a noise generator for generating white-Gaussian noise by the use of a noise diode.

In narrow-band digital communication systems, there is a correlation between a bit error rate of the narrow-band digital communication system and an Amplitude Probability Distribution (refered to A P D) of electro-magnetic interference waves. Moreover, a report was published that the bit error rate of the communication system can be evaluated from the A P D of electro-magnetic interference waves. In this report, noise determined by a specified A P D is generated by the use of an arbitrary distribution random number generator (See: Paper Journal of The Institute of Electrical Communication Engineers of Japan (A), vol. J 70-A, No.11, pp1681 -1690, Nov.1987).

Important parameters for defining characteristic natur of noise are the A P D , a Crossing Rate Distribution (refered to C R D), a Pulse Duration Distribution (refered to P D D), and a Pulse Spacing Distribution (refered to P S D) etc. These parameters will now be described with reference to Fig.13.

The A P D is defined as a time rate where the instantaneous value of a signal, such as electro-magnetic interference waves, exceeds a predetermined value, to show a total time length of the instantaneous value exceeding a level E_K in a test time period of T_0 . The C R D

is defined as a number of crossings per a unit time where the instantaneous value of the signal crosses the specified level E_K to a positive direction (or a negative direction).

The P D D is defined as a probability distribution of a time W_i (k) where the instantaneous value of the signal exceeds a level E_K in a test time period of T_0. On the contrary, the P S D is defined as a probability distribution of a time Z_i (k) where the instantaneous value of the signal lowers a level E_K in a test time period of T_0. In other words, the P D D and the P S D are probability distributions of time lengths from a time where the instantaneous value of the signal crosses the threshold level to a just succeeding time where the instantaneous value of the signal crosses the threshold level.

Moreover, a Probability Density Function is defined as a distribution of the level E_K in the test time period of T_0 .

In a pseudo noise generator, the dispersion and the average of noise can be specified, but the A P D of noise cannot be specified since distribution of noise is limited to the white-Gaussian noise.

In an arbitrary distribution random generator, the A P D of noise be specified to generate noise with an arbitrary A P D. However, noise from the arbitrary distribution random generator assumes independent events having no time-correlation. On the contrary, noise from elctronic Ranges and ordinary electronic devices assumes non-independent events dependent to the period of a source voltage and the period of timing clock pulses. Accordingly, the C R D, the P D D and the P S D of noise from the arbitrary distribution random generator are different from the C R D, the P D D and the P S D of noise of non-independent events having time-correlation.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a pseudo noise

generator capable of specifying a Pulse Duration Distribution and a Pulse Spacing Distribution of noise at a specified amplitude level K in addition to an Amplitude Probability Distribution of noise.

To this end, a pseudo noise generator of the present invention comprises :

a first arbitrary random number generator for generating two groups of first random number signals respectively corresponding to divided Amplitude Probability Distribitions, which are obtained by dividing a specified Amplitude Probability Distribition into two parts at a specified level;

a second arbitrary random number generator for generating two groups of second random number signals respectively defined by a specified Pulse Duration Distribution and a specified Pulse Spacing Destribution at the specified level;

control means for selecting ones of said two groups of first random number signals in accordance with said specified Pulse Duration Distribution and said specified Pulse Spacing Destribution defined at the specified level; and

a D/A converter for converting the selected signals to pseudo noise of analog value; said pseudo noise being generated in accordance with said Amplitude Probability Distribition, and said specified Pulse Duration Distribution and said specified Pulse Spacing Destribution at the specified level.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described in detail below with reference to the accompanying drawings, in which;

Fig.1 is a block diagram explanatory of the principle of the present invention;

Fig.2 is a block diagram illustrating an embodiment of the present

invention;

Fig.3 is a block diagram illustrating an example of an arbitrary distribution random number generator 1;

Fig.4 is a block diagram illustrating an example of each bit generator employed in arbitrary distribution random number generators 1 and 2;

Fig.5 is a graph showing arrangement of data in a memory in the bitgenerator;

Fig.6 is a block diagram illustrating an example of the arbitrary distribution random number generator 1 and time charts explanatory of operations of the same;

Fig.7 is a block diagram illustrating an example of the arbitrary distribution random number generator 2 and time charts explanatory of operations of the same;

Fig.8 is a block diagram illustrating an example of the controller 3and time charts explanatory of operations of the same;

Fig.9 shows characteristic curves illustrating conventional test results of the Amplitude Probability Distribition (a) , the Crossing Rate Distribution (b) and the Probability Density Function (c) of electro-magnetic interference waves from electronic Ranges and pseudo noise in case of specifying the electro-magnetic interference waves from electronic Ranges and the Amplitude Probability Distribition;

Fig.10 shows characteristic curves illustrating conventional test results of the Pulse Duration Distribition of electro-magnetic interference waves from electronic Ranges and pseudo noise in case of specifying the electro-magnetic interference waves from electronic Ranges and the Amplitude Probability Distribition;

Fig.11 shows characteristic curves illustrating the present invention's test results of the Amplitude Probability Distribition (a) ,

the Crossing Rate Distribution (b) and the Probability Density Function (c) of electro-magnetic interference waves from electronic Ranges and pseudo noise in case of specifying the electro-magnetic interference waves from electronic Ranges and the Amplitude Probability Distribition;

Fig.12 shows characteristic curves illustrating the present invention's test results of the Pulse Duration Distribition (a) and the Pulse Spacing Distribution (b) of electro-magnetic interference waves from electronic Ranges and pseudo noise in case of specifying the electro-magnetic interference waves from electronic Ranges and the Amplitude Probability Distribition; and

Fig.13 shows time charts explanarory of technical terms employed in this specification.

DETAILED DESCRIPTION

With reference to Fig.1, the principle of the pseudo noise generator of the present invention provided in accordance with a specified A P D, a specified P D D and a specified P S D will first be descrined. This pseudo noise generator of the present invention comprises four arbitrary distribution random number generators APD_1, APD_2, PDD_0 and PSD_0 and a selector SL.

In this case, setting of the P D D and the P S D is one point of the same level <u>k</u>; and an arbitrary distribution random number generator APD_1 for generating random numbers of values exceeding the level <u>k</u> and an arbitrary distribution random number generator APD_2 for generating random numbers of values under the level <u>k</u> are provided. These arbitrary distribution random number generators APD_1 and APD_2 are switched to meet with the specified P D D and P S D to generate random number codes meeting with required A P D, P D D and P S D. Namely, generation of pseudo noise according to the present invention is

performed as described below:

① Binary codes i_1 of N bits included in a pulse duration distribution pdd (i_1) is generated from the arbitrary distribution random number generator PDD_0 to determine a pulse duration length T_{i1}. During this pulse duration length T_{i1}, binary codes x_1 of M bits included in an amplitude probability distribution apd_1 (x_1) is generated from the arbitrary distribution random number generator APD_1 to obtain pseudo noise $\underline{x}$.

② After the end of the pulse duration T_{i1}, binary codes i_2 of N bits included in a pulse duration distribution psd (i_2) is generated from the arbitrary distribution random number generator PSD_0 to determine a pulse duration length T_{i2}. During this pulse duration length T_{i2}, binary codes $\underline{x}_2$ of M bits included in an amplitude probability distribution apd_2 (x_2) is generated from the arbitrary distribution random number generator APD_2 to obtain an outout of pseudo noise $\underline{x}$.

③ The above steps ① and ② are alternately performed.

In accordance with the above operations, binary numbers $\underline{x}$ of M bits meeting with the required A P D in addition to the required P D D and P S D are generated, and digital-to-analog converted to obtain an output of the pseudo noise generator.

As mentioned above, in the pseudo noise generator of the present invention, an arbitrary distribution random number generator 100 for generating exclusively the binary codes x_1 of M bits included in an amplitude probability distribution apd_1 (x_1) or the binary codes x_2 of M bits included in an amplitude probability distribution apd_2 (x_2) is employed in place of an arbitrary distribution random number generator for genarating a signal $\underline{x}$ included in a specified amplitude probability distribution (x).

A controller for outputting a memory selecting signal $\underline{s}$ is provided to selet a first state generating the binary codes x_1 or a second state generating the binary codes x_2 .

An arbitrary distribution random number generator 200 is provided for generating exclusively the binary codes i_1 of M bits included in a pulse duration distribution pdd_1 (i_1) or the binary codes i_2 of M bits included in a pulse spacing distribution psd (i_2) to generate the memory selection signal $\underline{s}$ employed in the controller. Setting of the pdd_1 (i_1) and the psd (i_2) is one point of the same level $\underline{k}$.

A digital-analog converter is provided to convert the binary codes $\underline{x}$ (x_1 or x_2) to an analog value. An analog signal converted in the digital-analog converter is applied to an communication system through a cable or is radiated from an antenna by shifting the frequency band of the thereof by the use of an up-converter.

In the pseudo noise generator according to the present invention, the binary codes i_1 included in a pulse duration distribution pdd_1 (i_1) is generated from the arbitrary distribution random number generator 200. During the pulse duration length T_{i1} corresponding to the binary codes i_1, the binary codes x_1 included in an amplitude probability distribution apd_1 (x_1) is generated from the arbitrary distribution random number generator 100. Thereafter, the binary codes i_2 included in a pulse spacing distribution psd (i_2) is generated from an arbitrary distribution random number generator 200. During the pulse duration length T_{i2} ,the binary codes x_2 included in an amplitude probability distribution apd_2 (x_2) is generated from the arbitrary distribution random number generator 100. Switching between the amplitude probability distribution apd_1 (x_1) and the amplitude probability distribution apd_2 (x_2) and switching between the pulse duration distribution pdd_1 (i_1) and the pulse spacing distribution psd (i_2) are

performed in accordance with the memory selection signal s from the selecter SL.

Since the amplitude level of the binary codes x_1 included in the amplitude probability distribution apd_1 (x_1) exceeds the value k while the amplitude level of the binary codes x_2 included in the amplitude probability distribution apd_2 (x_2) lowers the value k, the setting of the P D D and the P S D at the amplitude level k is carried out in the pulse duration length T_{i1} and the pulse duration time length T_{i2}, respectively.

The amplitude probability distribution apd_1 (x_1) and the amplitude probability distribution apd_2 (x_2) are calculated from the amplitude probability distribution apd (x). If the amplitude probability distribution apd (k), the pulse duration distribution pdd_1 (i_1) and the pulse spacing distribution psd (i_2) meet with the condition defined by an equation (1), the binary codes x (x_1 or x_2) generated from the arbitrary distribution random number generator 100 is included in the amplitude probability distribution apd (x). In this case, the notation M is a number of bits of the binary codes x (x_1 or x_2) generated from the arbitrary distribution random number generator 100, and the notation N is a number of bits of the binary codes i (i_1 or i_2).

$$\sum_{i_2=0}^{2^N-1} \mathrm{psd}(i_2) T_{i2} = \frac{1-\mathrm{apd}(k)}{\mathrm{apd}(k)} \sum_{i_1=0}^{2^N-1} \mathrm{psd}(i_1) T_{i1} \qquad (1)$$

In the present invention, designation of the pulse duration distribution P D D and the pulse spacing distribution P S D is not limited to designation of distribution having a distribution duration, but can be included designation of a special example of distribution having a defined value, as far as meeting with the condition of the equation (1).

(Embodiments)

In Fig.2, an embodument of the pseudo noise generator o present invention is illustrated. In this embodiment, arbitra distribution random number generators of eight bits are employed. The embodiment comprises an arbitrary distribution random number generator 1, an arbitrary distribution random number generator 2, a controller 3 and a digital-to-analog (D/A) converter 4. The arbitrary distribution random number generator 1 is controlled by clock (1) and the memory selection signal $\underline{s}$ from the controller 3. The arbitrary distribution random number generator 2 is controlled by clock (2) and the memory selection signal $\underline{s}$ which are applied from the controller 3. The D/A converter 4 converts thebinary codes $\underline{x}$ to an analog signal.

With reference to Fig.3, the arbitrary distribution random number generator 1 comprises eight bit generators 1-1 to 1-8 and eight latch circuits 1-11 to 1-18 to generate the binary codes $\underline{x}$ (x_1 or x_2) of eight bits, in which the eight bit generators 1-1 to 1-8 and eight latch circuits 1-11 to 1-18 are alternately connected in cascade so as to actuate each of the bit generators 1-1 to 1-8 at the rise-up instants of each clock pulses.

As shown in Fig.4, each of the eight bit generators 1-1 to 1-8 comprises a uniform random number generator 11, a memory 12, and a comparator 13. In the memory 12, data $\underline{y}$ employed for determining each bit (a, b, ...h) of the binary codes $\underline{x}$ (x_1 or x_2) are stored as follows.

The amplitude probability distribution apd$_1$ (x_1) correspods to a limited part of the binary codes $\underline{x}$ (x_1) in the amplitude probability distribution apd (x) to generate the binary code x_1 , which is included in a range $k \leqq x$. The amplitude probability distribution apd$_1$ (x_1) is defined in an equation (2).

$$\mathrm{apd}_1(x_1)=\begin{cases} 1 & (0 \leqq x_1 < k) \\ \dfrac{\mathrm{apd}(x_1)}{\mathrm{apd}(k)} & (k \leqq x_1 \leqq 2^8-1) \end{cases} \qquad (2)$$

The amplitude probability distribution apd_2 (x_2) correspods to a limited part of the binary codes $\underline{x}$ (x_2) in the amplitude probability distribution apd (x) to generate the binary code x_2 , which is included in a range $k > x$. The amplitude probability distribution apd_2 (x_2) is defined in an equation (3).

$$\mathrm{apd}_2(x_2)=\begin{cases} \dfrac{\mathrm{apd}(x_2)-\mathrm{apd}(k)}{\mathrm{apd}(0)-\mathrm{apd}(k)} & (0 \leqq x_2 < k) \\ 0 & (k \leqq x_2 \leqq 2^8-1) \end{cases} \qquad (3)$$

The amplitude probability distribution apd_1 (x_1) and the amplitude probability distribution apd_2 (x_2) calculated in accordance with the steps defined in the equations (2) and (3) are converted to Conditional Probalitities $pc_1(j,r)$, pc_2 (j,r) and then stored as data_y for determining each bit in the memory 5 as shown in Fig.5. In this case, the notation_j= 1,2,....8 and the notation_r = 0, 1,.....$2^{j-1}-1$.

$$pc_1(j,r) = \frac{\mathrm{apd}_1((2r+1)\cdot 2^{M-j}) - \mathrm{apd}_1((2r+2)\cdot 2^{M-j})}{\mathrm{apd}_1((2r\cdot 2^{M-j}) - \mathrm{apd}_1((2r+2)\cdot 2^{M-j})} \qquad (4)$$

$$pc_2(j,r) = \frac{\mathrm{apd}_2((2r+1)\cdot 2^{M-j}) - \mathrm{apd}_2((2r+2)\cdot 2^{M-j})}{\mathrm{apd}_2((2r\cdot 2^{M-j}) - \mathrm{apd}_2((2r+2)\cdot 2^{M-j})} \qquad (5)$$

With reference to Figs.6 and 4, operations of the arbitrary distribution random number generator 1 will be described.

In the arbitrary distribution random number generator 1, bit data

$A(s_1, a_1)$ from a first bit generator 1-1 is applied through a latch 1-11 to a second bit generator 1-2 at the rise instant of each pulse of the clock (1). The signal s_1 is the memory selection signal s, and the signal a_1 is a first bit a of the binary codes x from the first bit generator 1-1.

At the same time as the rise instant of each pulse of the clock (1), the uniform random number generator 11 in the second bit generator 1-2having the construction shown in Fig.4 generates uniform random numbers z. Thereafter, the data y employed in the second bit generator 1-2 are read out from the memory 12 by the use of the bit data $A(s_1, a_1)$ as address data. The data y and z are compared with each other, so that a second bit b_1 of an arbitrary distrinution number x at the output of the comparator 12 assumes a state "1" in case of $y < z$, while the second bit b_1 assumes the state "0" in case of $y \geqq z$.

The second bit generator 1-2 applies bit data $B(s_1, a_1, b_1)$ to a third bit generator 1-3 (not shown) at the just suceeding rise instant of each pulse of the clock (1). New bit data of (s_2, a_2) are applied from the first bit generator 1-1 to the second bit generator 1-2, which generates second bit data b_2 at the just succeeding clock pulse in response to the bit data of (s_2, a_2).

Each of other bit gernerators generates corresponding bit data from the bit data applied from a bit generator of the just preceding stage, so that the bit data applied from the bit generator of the just preceding stage are combined with bit data generated at the bit generator of instant stage, the combined bit data are applied to a bit generator of the just suceeding state.

In this case, since the first bit generator 1-1 is of a first stage, only the memory selection signal s is applied to the first bit generator 1-1 as shown in Fig.6 in place of bit data to be applied from a just

preceding stage. Since a bit generator 1-8 is of a last stage, the memory selection signal s is not necessarily applied to a next stage. Accordingly, data x (x = a,b,....,h) from which the memory selection signal s is removed are applied to the D/A converter as shown in Fig.6.

In accordance with the operations mentioned above, the arbitrary distribution random number generator 1 generates the binary code x_1 included in the amplitude probability distribution apd_1 (x_1) in synchronism with the pulse of the clock (1) in case of the state "1" of the memory selection signal s from the controller 3. In case of the sate "0" of the memory selection signal s from the controller 3, the binary code x_2 included in the amplitude probability distribution apd_2 (x_2) in synchronism with the pulse of the clock (1).

With reference to Fig.7, construction and operations of the arbitrary distribution random number generator 2 will now be desribed. This arbitrary distribution random number generator 2 generates, alternately,the binary codes i_1 employed for determining the pulse duration time length T_{i1} of the binary codes x_1 included in the amplitude probability distribution apd_1 (x_1), or the binary codes i_2 employed for determining the pulse duration length T_{i2} of the binary codes x_2 included in the amplitude probability distribution apd_2 (x_2).

This arbitrary distribution random number generator 2 has the construction and operations similar to those of the arbitrary distribution random number generator 1. In this arbitrary distribution random number generator 2, however, the clock (2) is employed in place of the clock (1). In each memory 12 of bit generators 2-1 to 2-8, data for generating the pulse duration distribution pdd_1 (i_1) and the pulse spacing distribution psd (i_2) in place of the amplitude probability distribution apd_1 (x_1) and the amplitude probability distribution apd_2 (x_2). From a function n (T_{i1}

) of a number n and the pulse duration length T_{i1}, the pulse duration distribution pdd_1 (i_1) can be calculated in accordance with an equation (6).

$$pdd(i_1) = \frac{n(T_{i1})}{\Sigma n(T_{i1})} \qquad (6)$$

The pulse spacing distribution psd (i_2) is calculated in the similar manner to those of the pulse duration distribution pdd_1 (i_1) in accordance with an equation (7).

$$psd(i_2) = \frac{m(T_{i2})}{\Sigma m(T_{i2})} \qquad (7)$$

The pulse spacing distribution psd (i_2) and the pulse duration distribution pdd_1 (i_1) are converted in accordance with equations (8) and (9) to trial conditional probability values $pc_1(j,r)$ and $pc_2(j,r)$, which are stored in the memory of the arbitrary distribution random number generator 2. In this case, the binary codes i_1 and i_2 are defined by bit signals j and r in the equation (8). However, the bit signals j and r aredefined as $j=1,2,\ldots,8$ and $r=0,1,\ldots.2^{j-1}-1$. The bit signal r is determined by trial results until the (j-1)-th trial. Data arrangement in the memory 12 of each bit generation 2-1 to 2-8 is shown in Fig.5 in the similar manner to the arbitrary distribution random number generator 1.

$$pc_1(j,r) = \frac{pdd((2r+1)\cdot 2^{8-j}) - pdd((2r+2)\cdot 2^{8-j})}{pdd(2r\cdot 2^{8-j}) - pdd((2r+2)\cdot 2^{8-j})} \qquad (8)$$

$$pc_2(j,k) = \frac{psd((2r+1)\cdot 2^{8-j}) - psd((2r+2)\cdot 2^{8-j})}{psd(2r\cdot 2^{8-j}) - psd((2r+2)\cdot 2^{8-j})} \qquad (9)$$

With reference to Fig.8, the controller comprises an I-T converter

20 receiving the binary codes i , a down counter 21 of 32 bits receiving output data T_* of the I-T converter 20 under control of the clock (1), a memory selection signal generator 22 receiving the carry output c of the down counter 21, and a clock generator 23 receiving the carry output c of the down counter 21 and the clock (1). The I-T converter 20 is a memory for data of thirty-two bits which is controlled with address codes i (= i_1 or i_2) of eight address bits to read out the stored data T_* ($*$ = i_1 or i_2).

The controller 3 sets the memory selection signal s to the state "1" during the time length T_{i1} and to the state "0" during the time length T_{i2} to control the pulse duration length T_{i1} of an arbitrary distribution random number included in the amplitude probability distribution apd_1 (x_1) and the pulse duration length T_{i2} of an arbitrary distribution random number included in the amplitude probability distribution apd_2 (x_2) as shown in time charts of Fig.8.

If the memory selection signal s assumes the state "1", the counting value c of the down counter 21 is decreased by "1". In this period of the state "1", the arbitrary distribution random number generator 1 generates the amplitude probability distribution apd_1 (x_1).

When the counting value c of the down counter 21 reaches the zero state, the memory selection signal s assumes the state "0". In this period of the state "0", the arbitrary distribution random number generator 1 generates the amplitude probability distribution apd_2 (x_2).

In response to the zero state of the down counter 21, the pulse duration length T_{i2} is newly set in the down counter 21 at the rise instant of a just succeeding pulse of the clock (1). At the same time as the zero state of the down counter 21, a pulse p_2 of the clock (2) comes at the rise instant of a just succeeding pulse of the clock (1) to actuate the arbitrary distribution random number generator 2 so as

to newly generate the binary code i_1', which is converted to the output data T_1' in the I-T converter 20.

The controller 3 descreases successively the conting value of the down copunter 21 as the similar manner to the case of the state "1" of the memory selection signal $\underline{s}$. In this period, the arbitrary distribution random number generator 1 generates the binary code x_2 included in the amplitude probability distribution apd_2 (x_2). When the counting value of the down counter 21 reaches the zero state, the state "0" of the memory selection signal $\underline{s}$ is reversed to the state "1", so that the output data T_1' is set to the down counter 21 to be restored to the initial state.

As mentioned above, the pulse duration length T_{i1} and the pulse duration length T_{i2} are alternately set to the down couinter 21 in the controller 3 to alternately reverse the state "1" and the state "0" of the memory selection signal $\underline{s}$ in response to the pulse duration length T_{i1} and the pulse duration length T_{i2}, respectively, so that the binary code x_1 included in the amplitude probability distribution apd_1 (x_1) and the binary code x_2 included in the amplitude probability distribution apd_2 (x_2) are alternately generated.

Simulation results of pseudo noise generation by a computer associated with the device of the present invention will be described. In this simulation test, the A P D, the P D D and the P S D of the electro-magnetic interference waves from an electronic range are measured and adopted. Since the measured values of the A P D, the P D D and the P S D are are obtained from actual electro-magnetic interference waves, these measured values meets necessrily with the condition of the equation (1). Figs.9A, 9B, 9C and Fig.10 are simulation results of pseudo noise distributions by conventional devices, where only the electro-magnetic interference waves from an electronic

range and the A P D are specified. A characteristic curve of heavy line in Fig.9A indicates the A P D of the electro-magnetic interference waves from an electronic range and is adopted as the A P D by conventional devices. A characteristic curve of heavy line in Fig.9B indicates the C R D of the electro-magnetic interference waves from an electronic range, and a characteristic curve of heavy line in Fig.9C indicates the P D F of the electro-magnetic interference waves from an electronic range. By using marks ○, △ and × in Figs.9A, 9B and 9C, the A P D, the C R D and the P D F of the pseudo noise are illustrated. In Fig.10, the P D D of the actual electro-magnetic interference waves and the P D D of the pseudo noise are illustrated with a heavy line and marks ●, respectively. As understood from Fig.s. 9A, 9B, 9C and 10, the actual electro-magnetic interference waves and the pseudou noise are substantially agreeable with each other with respect to the A P D and the P D F but different from each other with reference to the C R D and the P D D.

On the contrary, Figs. 11A, 11B and 11C and Fig.12 show test result of pseudou noise according to the present invention in case of specifying the actual electro-magnetic interference waves and the A P D, the P D D and the P S D. A heavy line in Fig.11A indicates the A P D of the actual electro-magnetic interference waves and is employed as a specified value of the A P D. A heavy line in Fig.11B indicates the C R D of the actual electro-magnetic interference waves, while a heavy line in Fig.11C indicates the P D F of the actual electro-magnetic interference waves. In Figs. 11A, 11B and 11C, marks ○, △ and × indicates the A P D, the C R D and the P D F of the actual electro-magnetic interference waves, respectively. In Fig.12A, a heavy line indicates the P D D of the actual electro-magnetic interference waves, while a heavy line indicates the P S D of the actual electro-magnetic

interference waves. In Figs.12A and 12B, the P D D and the P S D of pseudou noise generated in case of the P D D and the P S D specified are indicated by marks ○ and ×, respectively. As understood from Fig. 11A to Fig.12B, the actual electro-magnetic interference waves and the pseudou noise are substantially agreeable with each other with respect to the P D D and the P S D in addition to the A P D and the P D F but still different from each other with reference to the C R D .

As mentioned above in detals, noise of non-independent events having time-correlation of desired characteristics can be generated in accordance with the present invention of relatively simplified construction and control operations by designating the amplitude probability distribution apd(x), the pulse duration distribution $pdd_1(i_1)$ and the pulse spacing distribution psd (i_2). Therefore, merits of the present invention are very effective for evaluate immunity of electric devices against electro-magnetic interference waves.